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ABSTRACT

In an experiment to investigate learning styles in mathematics, 406 eighth grade students studied two sets of programed materials, one on triangles and one on quadrilaterals. Each program was available in two instructional styles: inductive and deductive. Students were stratified by sex and report card grades, and then assigned randomly to various combinations of one inductive and one deductive program. After elimination of 108 students for various reasons, the remaining 298 students were classified by results on the program posttests. Thirty-two deductive learners (those who had a high score after a deductive program and a low score after an inductive program) and 22 inductive learners (the opposite) were identified. Two further programs were then studied by these 54 students, one inductive and one deductive, but no significant differences appeared on these posttests. It is suggested that differential learning styles may be subject matter specific. (MM)

ABSTRACT

INDUCTIVE AND DEDUCTIVE LEARNING STYLES IN JUNIOR HIGH SCHOOL MATHEMATICS: AN EXPLORATORY STUDY

Programed materials were developed to investigate if 406 eighth grade subjects exhibited inductive and deductive learning styles in mathematics. Subjects above the median on the posttest following a concept taught inductively and below the median on the posttest following a concept taught deductively were classified as Inductive Learners. Subjects above the median on the posttest following a concept taught deductively and below the median on a posttest following a concept taught inductively were classified as Deductive Learners. 62 Ss scored above the median on both and 77 Ss scored below on both. 105 Ss scored at the median on one or both. The testing scheme resulted in the classification of 32 Deductive and 22 Inductive Learners. 2 additional programs were administered to these students. 1 utilized an inductive strategy and the other a deductive strategy. Posttests of achievement were administered for the additional programs. No significant difference between groups was found.

INDUCTIVE AND DEDUCTIVE LEARNING STYLES IN JUNIOR HIGH SCHOOL MATHEMATICS: AN EXPLORATORY STUDY

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Many research studies have been concerned with an investigation of how problem solving is learned and how it can be taught (Kilpatrick, 1969). Although the nature of the problem solving activities of mathematicians is varied, there is historical or philosophical justification for a dichotomization of this problem solving activity. Hadamard (1949) commented about students of mathematics that "Not only do these differ from ordinary students, but they also profoundly differ from each other. A capital distinction has been emphasized: some mathematicians are intuitive, others logical." These different problem solving approaches may be indicative of individual learning styles.

This study was an investigation of the existence and the effect on mathematics achievement of individual learning styles categorized as inductive and deductive.

Method

For the purposes of this investigation induction was defined as "a process of using evidence concerning some members of a class of objects as a basis for an assertion about all or more members of that class (Black, 1952)." The Method of Agreement in which the generalization has the form that every case of A, no matter what else is the case, is also

a case of B, was the particular mode of induction used (Black, 1952). For example in one inductive program the sum of the measures of the interior angles of a right triangle, an acute triangle, and an obtuse triangle were found. In each triangle the sum was found to be 180^{o}.

Deduction was defined for the purposes of this study as a series of arguments that aims at valid conclusions. An argument is said to be valid when it is impossible for all the premises to be true while the conclusion is false.

The subjects were 406 eighth grade students enrolled in a Minneapolis, Minnesota, junior high school. The regular fall (1970) testing program included administration of the Gates-MacGinitie Reading Test and the Modern Mathematics Supplement to the Iowa Tests of Basic Skills. The national public school ranking placed their median performance at the 58th percentile on both the vocabulary and the comprehension sections of the Gates-MacGinitie and at the 49th percentile on the Modern Mathematics Supplement.

Subjects were first administered a Buffer Program of Prerequisite Skills (Gawronski, 1971), which had a two-fold purpose. It was designed to introduce the subjects to programed learning materials and to review and/or instruct on skills identified as prerequisite for the programs which followed.

All of the materials used in this study were developed by the experimenter and were first field tested in a pilot study (Gawronski, 1971). The pilot study was conducted at the secondary laboratory

school affiliated with the University of Minnesota, Minneapolis, Minnesota. At the conclusion of the pilot study the materials were revised where necessary.

At the conclusion of the Buffer Program a test of prerequisite skills and the pretests for the following programs were administered. Inductive and deductive versions (Gawronski, 1971) were prepared for the concepts:

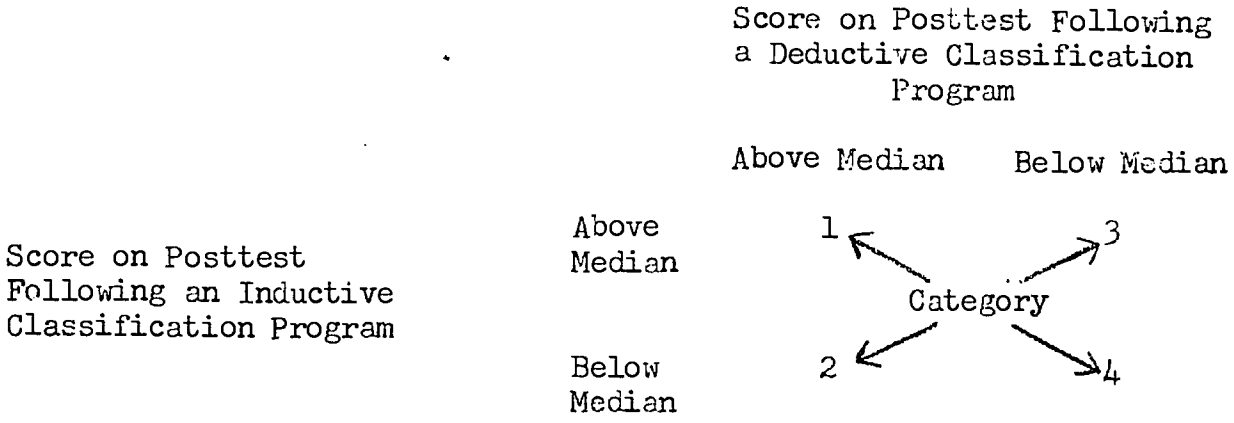
1. The sum of the measures of the interior angles of a triangle is equal to 180°.
2. The sum of the measures of the interior angles of a quadrilateral is equal to 360°.

The subjects in each class were stratified according to sex to insure a reasonable distribution of sexes in each of the groups. This also provided that if sex were an important variable, it would not be neglected. Subjects were also stratified according to their first quarter report card grades in mathematics. They were then randomly assigned to one of the following sequences of programed instruction:

1. Inductive-Triangle; Deductive-Quadrilateral.
2. Deductive-Triangle; Inductive-Quadrilateral.
3. Inductive-Quadrilateral; Deductive-Triangle.
4. Deductive-Quadrilateral; Inductive-Triangle.

A posttest on the concept taught in the program was administered at the conclusion of each program. The scores of the posttests were used to establish the categories 1-4, given in Figure 1.

Figure 1. Category Classification Scheme



The subjects who scored at the median on one or both of the classification posttests were not classified and were eliminated from further study.

The subjects in Category 3 were called Inductive Learners and the subjects in Category 2 were called Deductive Learners. Subjects in Categories 1 and 4 were called High High Learners and Low Low Learners respectively. Each subject was administered two additional programs of instruction (Gawronski, 1971) in a random order. One program utilized an inductive strategy and the other a deductive strategy. These programs were:

1. Inductive-Pythagorean Theorem and its converse.
2. Deductive-Area of a triangle, the development of the formula and applications.

A posttest on the concept taught in each program was administered at the conclusion of each program. It was expected that the mean performance of the Inductive Learners would be significantly higher than the mean performance of the Deductive Learners on the posttest following the Inductive-Pythagorean Theorem program. Similarly, it was expected that the mean performance of the Deductive Learners would be

significantly higher than the mean performance of the Inductive Learners on the posttest following the Deductive-Area of a Triangle program.

Posttests

Criterion behaviors were identified for each of the concepts taught in the programs. Item forms were developed for each of these behaviors and then used to generate the test items (Gawronski, 1971). This domain referenced achievement testing system was used to measure student performance (Hively, Patterson, & Page, 1968). The criterion behaviors identified for the programs were of a low cognitive level. For example in the Triangle Programs the criterion behaviors included finding the measure of the third angle of triangle given the measures of two of the angles. Each of the posttests following the classification programs and the additional treatment programs contained 12 items.

Results

Data from 381 eighth grade subjects were considered in the analysis of the results. Data were not collected from 25 subjects for several reasons which included unknown previous mathematics achievement score due to recent transfer to the school, extreme reading difficulties, expulsion or suspension during the course of the study, excessive absences from school or identification by their teacher as emotionally disturbed.

The data from the 381 who actually participated in the study were first analyzed to eliminate those subjects who scored less than 50% on the test of prerequisite skills (22 item test) or who scored greater

than 50% on one or more sections of the four part pretest (10 items in each section). The data indicated that 28 or 7.35% of the subjects were eliminated because of their prerequisite skills test score and 55 or 14.44% were eliminated because their pretest score was too high. Forty-seven of these 55 subjects had a pretest score greater than 50% on both the Triangle and Quadrilateral sections of the pretest.

The following analyses were performed on the data from the remaining 298 subjects. Data from posttests following the classification programs were analyzed separately for male and female subjects. The frequency distributions for these results are presented in Figure 2. The frequency distributions for each of the posttests showed a dispro-

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Insert Figure 2 about here

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portionate number of high scores indicating distributions that are skewed to the left. In each pair of frequency distributions presented in Figure 2, there were more high scores for the triangle posttest results than for the quadrilateral posttest results.

The means and standard deviations for the results of these Classification Programs are presented in Table 1.

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Insert Table 1 about here

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The results of the Classification Programs posttests were used to identify subjects as Inductive Learners, Deductive Learners, High High

Learners or Low Low Learners. The distribution of subjects in each of these categories is presented in Table 2. There were 62 High High

Insert Table 2 about here

Learners, 27 male and 35 female. Seventy-seven subjects were classified as Low Low Learners, 40 male and 37 female. There were 105 subjects, 46 male and 59 female, who were not classified because they scored at the median on one or both of their classification tests. There were 22 subjects, 11 female and 11 male, who could be classified as Inductive Learners. There were 32 subjects who could be classified as Deductive Learners, 17 male and 15 female.

The classification results for the 104 subjects who were classified on the posttests following the Triangle-Inductive and Quadrilateral-Deductive programs are presented in Table 3.

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Insert Table 3 about here

There were 34 High High Learners and 39 Low Low Learners, 16 Deductive Learners and 15 Inductive Learners. A Pearson Chi-square test of association (Hays, 1963) was used to test the hypothesis that the categorical attributes were independent. Using Yates' correction for continuity (Hays, 1963) a Chi-square value of 14.6 ($p < .001$) was obtained. Hence the hypothesis was rejected.

The classification results for the 89 subjects who were classified on the Quadrilateral-Inductive and Triangle-Deductive posttests results are presented in Table 4. There were 28 High High Learners, 38 Low

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Insert Table 4 about here

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Low Learners, 16 Deductive Learners and 7 Inductive Learners. A Pearson Chi-square test with Yates' correction for continuity was used to test the hypothesis that the categorical attributes were independent. The Chi-square value of 19.6 ($p < .001$) indicated rejection of this hypothesis.

When the results of these two classification schemes were combined there were 62 High High Learners, 77 Low Low Learners, 32 Deductive Learners and 22 Inductive Learners. It was hypothesized that if ability were an important contribution factor then the expected frequencies would be high in the High High and Low Low categories and low in the Inductive and Deductive Learner categories. The particular frequencies selected as expected were 86 High High Learners, 87 Low Low Learners, 10 Inductive Learners and 10 Deductive Learners. Ten was selected for the number of Inductive and Deductive Learners since this is a suggested minimum expected cell frequency for use of this test (Hays, 1963). The Chi-square value obtained was 70.6, which has a probability value of less than .001. Hence this hypothesis was also rejected.

The distribution of previous mathematics achievement scores for the Inductive and the Deductive Learners was not found to be different (Gawronski, 1971). Data from these 54 subjects were considered from the results of the posttests following the two additional treatment programs. The results for the Inductive and the Deductive Learners were compared separately for each of the sexes for each of the treatment programs. A two sample t statistic was used to compare the mean scores of the two groups in each case. The results of the posttests for these two additional programs are presented in Table 5.

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Insert Table 5 about here

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The mean scores of the female Inductive Learners and the female Deductive Learners were equal on the posttest following the Inductive treatment program. The t statistic calculated from these data was $t = 0.0$, $p > .80$ (2 tailed; 24 df).

The mean score for the female Inductive Learners was higher than that of the female Deductive Learners on the posttest following the Deductive treatment program. The t statistic calculated from these data was $t = -0.810$, $0.2 < p < 0.5$ (2 tailed; 24 df).

The mean score for the male Inductive Learners was higher than the mean score of the male Deductive Learners on the results of the posttest

following the Inductive treatment program. The t statistic calculated from these data was $t = 0.325$, $0.5 < p < 0.8$ (2 tailed; 26 df).

The mean score of the male Inductive Learners was higher than the mean score of the male Deductive Learners on the posttest following the Deductive treatment program also. The t statistic calculated from these data was $t = -0.141$, $p > 0.8$ (2 tailed; 26 df).

The t statistics obtained from these data indicated no significant differences between group scores on these additional measures.

Discussion

When the data from the 381 subjects were first analyzed it was necessary to eliminate 83 of the 381 subjects. Twenty-eight of these had a prerequisite skills test score less than 50%. This was not considered to be an excessive number of subjects. Fifty-five subjects were eliminated because their pretest scores on one or more sections of the pretest was greater than 50%. However, further analysis revealed that 47 of these subjects had scores greater than 50% on both the Triangle and Quadrilateral pretests. It seems probable that these subjects had been previously introduced to these topics. There were no subjects who had a prerequisite skills test score less than 50% and a pretest score greater than 50% which provides some evidence for the validity of the hierarchal structure identified for the instructional sequence.

The negatively skewed distribution results for the posttests following the classification programs are not surprising since the experimental materials were programmed. They had been programmed in an attempt to minimize the teacher effect. These four distributions were used to identify the Inductive and Deductive Learners. The numbers of each were similar for each pair of distributions.

There were a rather large number of unclassified learners. It is a characteristic of the classification system used that a subject who was at the median on either one or the other or both of the classification tests was placed in this category. Thus, there were five possible ways for being placed in this category. The skewed nature of the distributions indicated a high median and hence a large number of subjects were at the median score.

The Chi-square tests performed on the classifications obtained indicate that the phenomenon identified is not entirely explained by chance nor by the operation of an ability factor. It was hypothesized that major contributing factors were the inductive and deductive learning styles. The two additional programs were administered to the Inductive and the Deductive Learners in an attempt to contribute to the verification of this hypothesis.

The probability values for the t statistics calculated indicate little discernible difference in performance for the two groups on the additional programs. It is possible that the inductive-deductive categorization is subject matter specific. The concepts utilized in

the classification programs were geometric and very closely related. The concepts utilized in the two additional programs were not as closely related and were more algebraic than the concepts in the classification programs.

Another reason for the results obtained might be in the nature of the materials used. Although the programmed materials minimized the teacher effect, the distribution of the classification posttests tended to be extremely skewed. Since the median scores were very close to the maximum score, the classification scheme may be somewhat equivocal.

Although the results of the additional programs do not support the hypothesis of the inductive-deductive dichotomization of learning style, the classification scheme did indicate differential results for some subjects. There were 54 subjects who had markedly different results on the two posttests and were categorized. This does provide evidence for the inductive-deductive learning style phenomenon for some subjects.

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TABLE 1

CLASSIFICATION PROGRAM POSTTEST MEANS AND STANDARD DEVIATIONS

Classification Program	Sex					
	Male			Female		
	Mean	S.D.	n	Mean	S.D.	n
Inductive-Triangle	8.49	4.14	68	10.17	2.82	87
Deductive-Triangle	9.67	3.46	73	9.09	3.76	70
Inductive-Quadrilateral	8.39	2.72	73	8.31	3.44	70
Deductive-Quadrilateral	7.40	3.78	68	8.68	3.41	87

TABLE 2

LEARNING STYLE CLASSIFICATION

Programs	Classification									
	Inductive		Deductive		High		High		Low	
	M	F	M	F	M	F	M	F	M	F
Triangle-Inductive & Quadrilateral Deductive	5	10	8	8	13	21	22	17	20	31
Triangle-Deductive & Quadrilateral Inductive	6	1	9	7	14	14	18	20	26	28

TABLE 3

CLASSIFICATION SCHEME FOR TRIANGLE-INDUCTIVE AND QUADRILATERAL-DEDUCTIVE PROGRAMS

		Triangle-Inductive Program Posttest Score	
		Above Median	Below Median
Quadrilateral-Deductive Program Posttest Score	Above Median	34	16
	Below Median	15	39

TABLE 4

CLASSIFICATION SCHEME FOR TRIANGLE-DEDUCTIVE AND QUADRILATERAL-INDUCTIVE PROGRAMS

		Quadrilateral-Inductive Program Posttest Score	
		Above Median	Below Median
Triangle-Deductive Program Post-test Score	Above Median	28	16
	Below Median	7	38

TABLE 5

ADDITIONAL TREATMENT PROGRAM POSTTEST MEANS AND STANDARD DEVIATIONS

Program		Learning Style Classification					
		Inductive			Deductive		
		Mean	S.D.	n	Mean	S.D.	n
Inductive-Pythagorean Theorem	Male	6.55	4.99	11	6.00	3.94	17
	Female	5.73	3.23	11	5.73	2.81	15
Deductive-Area of a Triangle	Male	4.91	3.91	11	4.35	3.97	17
	Female	4.46	4.97	11	3.13	3.42	15

Figure Captions

Figure 2. Frequency Distribution of Classification Program Posttests. Broken line indicates a Deductive program and solid line indicates an Inductive program. Arrows indicate median scores.

a
Inductive-Triangle; Deductive-Quadrilateral

b
Inductive-Quadrilateral; Deductive-Triangle